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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of:

Richard G. Morton

Serial No.: 09/742,485

Filing Date: December 20, 2000

Title: ANNEALED COPPER ALLOY  
ELECTRODES FOR FLUORINE  
CONTAINING GAS DISCHARGE  
LASERS

Examiner: Monbleau, Davienne N.

Group Art Unit: 2878

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**APPLICANT'S SUBSTITUTE APPEAL BRIEF**

Applicant filed a Notice of Appeal in the above captioned application on February 12, 2004, Responsive to a Final Rejection dated January 12, 2004. Applicant received a Notification of Non-Compliance with 37 C.F.R. §1.192 (c).

Applicant hereby presents Applicant's Substitute Appeal Brief in accordance with the requirements of the Notification of Non-Compliance.

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**(1) Real Party In Interest**

The real party in interest in the above captioned application is Cymer, Inc. a corporation of the state of Delaware and the assignee of the above captioned application from the applicant named inventor.

**(2) Related Appeals and Interferences**

There are no related appeals or interferences.

**(3) Status of the Claims**

Claims 1-11 and 18-22 remain in the above captioned application. Claims 1-11 and 18-22 stand rejected and the Office Action is Final. Claims 12-17 were restricted out in an Office Action dated June 18, 2003, and cancelled by Amendment dated October 20, 2003, in which also claims 18-22 were added. The Claims on appeal are claims 1-11 and 18-22

**(4) Status of Amendments**

There have been no amendments filed after the Final Office Action of January 12, 2004.

**(5) Statement of the Invention**

As claimed the invention relates to a gas discharge excimer laser having an elongated machined and annealed copper alloy cathode and an elongated machined and annealed copper alloy anode." Claims 2-4 recite specific alloy content for an anode and claims 5-11 recite specific alloy content for a cathode. Claims 19-22 recite details of the annealing of the anode and cathode.

**(6) Issues**

1. Whether claims 1 and 18-22 are patentable under 35 U.S.C. §103 (a) over the United States Patent No. 5,729,565, entitled DISCHARGE UNIT AND ELECTRODE FOR A PULSED DISCHARGE LASER, issued to Meller et al. on March 17, 1998 based on an application 827,973, filed on November 7, 1996 ("Meller") and United States Patent No. 4,742,527, entitled LASER HAVING BRAZED ANODE, issued to Weidemann et al. on May 3, 1988, based on an application Ser. No. 735,560, filed on May 17, 1985 ("Weidemann"). This issue includes:

a. Whether the Examiner has even made a *prima facie* case for obviousness under 35 U.S.C. § 103 (a) over Meller in view of the Weidemann, since Weidemann is not analogous art to electrodes for gas discharge lasers such as excimer lasers.

b. Whether the Examiner has made out a case of *prima facie* obviousness since there is no suggestion to combine the cited references.

c. Whether the Examiner has even made a *prima facie* case for obviousness under 35 U.S.C. § 103 (a) over Meller in view of the Weidemann, since the combination of Meller and Weidemann fails to result in all of the claimed elements in the applicable claims.

d. Whether the Examiner was correct in ignoring the “product by process” recitations of claims 18-22.

2. Whether claims 2-11 are patentable under 35 U.S.C. §103 (a) over Meller, Weidemann and United States Patent No. 4,860,300, entitled ELECTRODE FOR PULSED LASERS, issued to Baumler et al. on August 22, 1989, based upon an application Ser. No. 303,083, filed on January 27, 1989 (“Baumler”).

This issue includes:

a. Whether the Examiner has even made a *prima facie* case for obviousness under 35 U.S.C. § 103 (a) over Meller in view of the Weidemann and Baulmer, since Weidemann is not analogous art to electrodes for gas discharge lasers such as excimer lasers.

b. Whether the Examiner has made out a *prima facie* case of obviousness since there is no suggestion to combine the cited references.

c. Whether the Examiner has even made a *prima facie* case for obviousness under 35 U.S.C. § 103 (a) over Meller in view of the Weidemann and Baulmer, since the combination of Meller and Weidemann and Baulmer fails to result in all of the claimed elements in the applicable claims.

d. Whether the Examiner has properly applied the “obvious to optimize” rejection as to claims 2-11.

### **(7) Claim Grouping**

Claims 1 and 18-22 stand together, having been rejected over Meller and Weidemann and claims 2-11 stand together having been rejected over Meller, Weidemann and Baumler.

### **(8) Argument**

#### **I) Facts**

As the Specification in the above captioned application notes, the present invention relates to:

An excimer laser with a laser chamber containing a circulating laser gas containing fluorine and long-life, annealed, copper alloy electrodes. ... This annealing relieves the surface stress ... and reduces the exposed metallic grain boundary length per unit area on the surface of the electrodes, which provides substantial reduction in erosion caused by fluorine chemical attack. In preferred embodiments the anode is a copper-aluminum alloy and the cathode is a copper-zinc alloy. (Abstract, p. 15, lines 2 – 10)

The Specification of the above captioned application also notes:

The principal components of a prior art KrF excimer laser chambers are shown in FIG. 1. This chamber is a part of a laser system used as a light source for integrated circuit lithography. These components include a chamber housing 2. The housing contains two electrodes cathode 84 and anode 83 each about 55 cm long and spaced apart by about 20 mm, a blower 4 for circulating a laser gas between the electrodes at velocities fast enough to clear (from a discharge region between the two electrodes) debris from one pulse prior to the next succeeding pulse at a pulse repetition rate in the range of 1000 Hz or greater. ... The laser gas is comprised of a mixture of about 0.1 percent fluorine, about 1.0 percent krypton and the rest neon. Each pulse is produced by applying a very high voltage potential across the electrodes with a pulse power supply which causes a discharge between the electrodes lasting about 30 nanoseconds to produce a gain region about 20 mm high, 3 mm wide and 525 mm long. ... The discharge deposits about 2.5 J of energy into the gain region. ... The energy of the output

pulse 3 in this prior art KrF lithography laser is typically about 10 mJ. (p. 1 line 7 – p. 2, line 5)

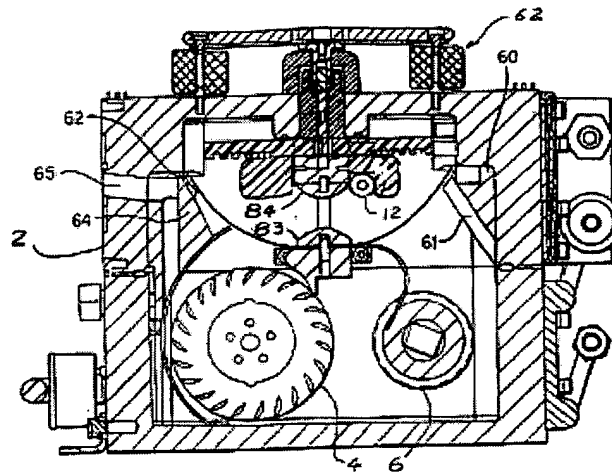


FIG. 1  
PRIOR ART

FIG. 3 shows an enlarged view of cathode 84 and anode 83. Each is about 3 cm wide but the discharge region 85 is only about 3 to 4 mm wide. ...

These KrF lithography lasers typically operate in bursts of pulses at pulse rates of about 1000 to 2000 Hz. Each burst consists of a number of pulses, for example, about 80 pulses, ... A laser operating at 2000 Hz "around the clock" at a 30 percent duty factor will accumulate more than 1.5 billion pulses per month. ...

Maintaining high quality of the laser beam produced by these lasers is very important because the lithography systems in which these laser light sources are used are currently required to produce integrated circuits with features smaller than 0.25 microns and feature sizes get smaller each year. Laser beam specifications limit the variation in individual pulse energy, the variation of the integrated energy of series of pulses, the variation of the laser wavelength and the magnitude of the bandwidth of the laser beam.

Typical operation of electric discharge laser chambers such as that depicted in FIG. 1 causes electrode erosion. Erosion of these electrodes affects the shape of the discharge which in turn affects the quality of the output beam as well as the laser efficiency. Typically, anode erosion in these excimer lasers is two to three times as severe as cathode erosion.

Electrode erosion is the result of a complex combination of physical phenomena including fluorine chemical attack and ion induced sputter. Use of alloys of copper for electrodes for gas discharge lasers is well known. For example, a common electrode material is a brass known as C36000 which is comprised of 61.5% copper, 35.5% zinc and 3% lead. It is known to anneal brass parts before they have been machined to make the parts less brittle.

The Specification goes on to explain: (p. 2, line 6, p. 3, line 13)

Electrode erosion and fluoride build up in prior art lasers typically becomes so severe that at about 5 to 10 billion pulses, the laser beam no longer meets quality specifications. At this time typically the laser chamber is replaced with a chamber with new electrodes. A replacement chamber costs several thousand dollars and replacement requires a temporary shutdown of integrated circuit production.

Most electric discharge lasers used for integrated circuit lithography utilize brass as the electrode material. Many other materials have been tested in efforts to discover better electrode material, but to the best of Applicant's knowledge none have been proven to be better than brass taking into consideration all costs including cost of laser manufacture and cost of operation. However, recent tests by Applicants' indicate that a high strength copper material containing submicron clumps of  $\text{Al}_2\text{O}_3$  sold under the trademark GLIDCOP.RTM. and available from OMG Americas with offices in Research Triangle Park, NC. Many otherwise excellent electrode materials are not compatible with the extremely reactive fluorine gas in these chambers. (p. 5, line 23 – p. 6, line 10)

#### Issues

There are five important issues to deal with in developing a better electrode for electric discharge lithography lasers using fluorine containing laser gas:

- 1) electrode erosion seriously affects beam quality,
- 2) electrode erosion currently limits laser chamber life,
- 3) anode erosion is about four times cathode erosion,

- 4) fluoride layer buildup on the anode is a problem, and
- 5) maintaining good gas flow conditions in the discharge gap is very important.

The various embodiments of the present invention described herein deal with these issues. The electrodes satisfy the following criteria:

- 1) the electrodes comprise an erosion surface which erodes slowly over several billion laser pulses with the erosion not substantially affecting beam quality,
- 2) the erosion surfaces resists fluoride insulation buildup on discharge regions, and
- 3) the electrodes are designed to provide improved gas flow to permit repetition rates of 1,000 Hz to 6,000 Hz or greater without substantial turbulence in the discharge region. (p. 7, lines 1-19)

The preferred embodiments of the invention are described in the Specification of the above captioned application as follows:

Applicant realized then that fluorine chemical attack of the copper alloys is concentrated at grain boundaries and that the surface heat treating was the cause of the temporary reduced fluorine caused erosion. Applicant then had machined electrode samples annealed thoroughly to temperature in the range of about 830° C. These samples were then tested as anodes and cathodes. When configured as anodes, the annealed samples exhibited substantially increased lifetime but when configured as cathodes the annealed samples exhibited longer lifetime but the difference was not substantial.

Applicant explains this unexpected result as follows: electrode erosion of the anode occurs primarily as a result of fluorine attack. This attack occurs in the first few nanoseconds of each pulse in a burst of pulses after the first pulse. During this time interval, the electric field in the fall region of the anode is extremely large due to the voltage potential of about 20,000 volts applied initially across the electrodes. The result is that a large portion of fluorine ions created by the previous pulse which remain in the fall region of the anode will be attracted to the anode surface at substantial velocity with a substantial portion of these ions chemically combining with the electrode atoms to produce fluorides which in turn erode away or may in some cases build up to interfere with performance.

Since the cathode is initially charged to a negative 20,000 volts, any fluorine ions in the fall region of the cathode will be repelled away so that fluorine caused erosion of the cathode is minor. (Some small amount of fluorine erosion probably results due in part to the voltage reversal that occurs at the tail end of the pulse (see FIG. 4B.)

Cathode erosion is caused primarily by sputtering caused by positive ions of Kr or Ne (for the KrF laser) or Ar or Ne (for the ArF laser) created in the fall region of the cathode. Applicant's subsequent examination of cathode copper based electrodes comprised of substantial portion of zinc indicates that some of the cathode erosion is due to zinc diffusion up to the surface.

Comparison examinations indicate that annealing of the cathode electrodes after machining reduces this zinc diffusion. Again Applicant's explanation of this phenomenon is that the reduction in the total grain boundary length reduces the tendency of the zinc to migrate to the surface.

For both the cathode and the anode it is important that the electrode be annealed after machining. Therefore, when we use the phrase "after machining annealed" we mean annealed after machining.

#### Choice of Copper Alloys

Applicant has conducted a substantial number of tests and research in an effort to select the best copper based alloy for use in the excimer lasers discussed in the background section. Prior art brass electrodes such as C36000 brass (61.5% Cu, 35.5% Zn and 3% Pb) exhibit lifetimes of about 2 billion pulses in an ArF laser and about 4 billion pulses in a KrF laser.

#### Preferred Anode

Applicant has discovered that aluminum bronze such as C63200 (82% Cu, 10% Al, 5% Ni and 3% Fe) is more resistant to fluorine attacks than prior art zinc brass such as C36000 brass (61.5% Cu, 35.5% Zn and 3% Pb). Therefore in one preferred embodiment of this invention Applicant recommends that the anode be fabricated using this C63200 aluminum-bronze and that the electrode be annealed after machining. Applicant recommended annealing process is as follows:



Heat anode at 830.degree. C. in inert atmosphere (e.g. N.sub.2 or a noble gas or in vacuum) for about 12 hours

Allow to cool slowly in oven for approximately 8 hours.

This recommended temperature is several hundred degrees higher than typical recommended brass part annealing temperatures, which are normally in the range of about 425.degree. C. to 600.degree. C. This typical recommended annealing temperature range is not sufficient for use of the alloys as electrodes, and is intended for mechanical parts fabrication such as gears, and the like.

#### Preferred Cathode

Applicant has tested the C63200 brass as a potential cathode electrode for these excimer lasers; however, Applicant's test indicate that the lifetime improvement indicated for the anode are not the same for the cathode and other copper based alloys are preferred for the cathode. Applicant expects that the aluminum in the cathode causes it to be more susceptible to sputter erosion and since sputter is the main cause of erosion of the cathode, heavier atoms are preferred for the cathode. Therefore, Applicant's preferred material for the cathode is C26000 brass (70% Cu, 29.93% Zn and 0.07% Pb). Another preferred material is C36000 brass which has been used by Applicant's employer for electrodes in its lasers for several years. These prior art electrodes were not annealed. Applicant's tests show that annealing the cathode after machining using the same procedure described above for the anode increases cathode lifetime. Applicant suspects that the increased cathode lifetime is a combined result of reduced zinc diffusion and some reduction in fluorine attack that occurs in the latter part of the discharge when the cathode functions as an anode. (p. 8, line 5 – p. 10, line 23)

In stark contrast to the above described invention and the environment in which it is utilized, Weidemann describes:

An ion laser is described having an anode construction which has no special configuration specifically designed to accommodate differential thermal expansion between it and a ceramic tube. The anode includes a radially thick first portion for good thermal conductivity and a thin-walled sleeve integral therewith extending beyond the tube to provide an exterior surface for electrical connection. (Abstract).

Weidemann also mentions:

The configuration of the electrode and of the tube at the electrode location assures that a good direct adherence is achievable with brazing. In this connection, expansion miss-match is accommodated by annealing of the metal, preferably copper, and by the geometrical configuration of the structure. Moreover, this configuration and the construction of the invention enables such direct adherence without the metal of the tube being configured to flex to accommodate differential thermal expansion. (Col. 1, line 68 – Col. 2, line 10).

Weidemann further states:

The metal of the electrode preferably is annealed to minimize internal stresses. If the electrode is of copper as is preferred, it automatically will be annealed when the construction is raised to the brazing temperature. (Col. 2, lines 29-32)

Weidemann describes in great detail the construction and fabrication of “the preferred embodiment of a gas ion laser incorporating the present invention” (Col. 3, lines 34-35) as follows:

As another salient feature of the invention, the electrode is provided with an electrically conductive surface at both the interior of the tube and at its exterior, and a conductive electrical connection is provided to the exterior surface. The result is that an electrical potential can be provided to the interior of the containment volume without penetration for leads for the electrode. Again, the configuration of the electrode enhances such construction.

The electrode preferably is an anode that includes a radially thick first portion having a radially thin-walled sleeve extending outwardly beyond the ceramic tube portion mentioned above providing the surface which is exposed to the exterior of the tube to which the conductive electrical connection is made. Most desirably, exterior connection is made by a conductor in the form of a ring or clamp circumscribing and mating with the exteriorly exposed sleeve surface. Supporting structure is provided within the interior of the anode to prevent collapse of the thin-walled sleeve under pressure of the connector clamp. Such support most simply is provided as the ceramic end tubing of a window structure located at the end of the tube having the anode. The exterior surface of the

ceramic end tubing of the window structure mates with the interior surface of the sleeve and thereby provides support.

The invention further includes a method of manufacturing the laser tube to enhance the electrode securance. It includes providing the ceramic tube having a cylindrical interior surface at one end, providing an electrode having a cylindrical outer surface whose axial dimension is greater than its radial dimension and thereafter directly adhering the two surfaces together. As mentioned previously, such adherence is preferably obtained by brazing and a greater axial extent of the exterior surface of the electrode than the radial dimension of such electrode, is brazed to provide such direct adherence. (Col. 2, line 51 – Col. 3, line 20)

Still further, Weidemann explains:

As a salient feature of the instant invention, it includes an anode electrode structure which has a configuration eliminating many of the limitations of past designs. The anode itself is of a metal to be a good electrical conductor and yet in keeping with the invention it is secured to the ceramic portion of the tube in a manner which assures good vacuum sealing. With reference to FIG. 2, the anode assembly 17 includes a ceramic cylinder or end cap 42 which is adhered directly to the ceramic bore 16. The cylinder 42 is also preferably of BeO and it will be recognized that a good vacuum tight mechanical securance to the bore 16 is achievable, particularly since there is essentially no different radial thermal expansion of the tube 16 end and cylinder 42 over to the temperature range to which the securance joint is subjected during normal usage of the laser.

The anode itself is cylindrical and is generally referred to by the reference numeral 43. It is made of OFHC copper for high electrical and thermal conductivity and good vacuum compatibility. In accordance with the invention, it is directly adhered to the ceramic of the tube (to the ceramic cylinder 42) without special steps being taken to accommodate differential thermal expansion between such electrode and the ceramic. In this connection, it will be recognized that there is significant differential thermal expansion between a metal and a ceramic. The securance is achieved with a vacuum-tight seal over a large surface area. To this end, the electrode 43 has an outer cylindrical surface 44 whose axial dimension is

greater than its radial dimension a portion of which mates with and is brazed to the interior surface 46 of the ceramic cylinder 42. As an example, in one embodiment the anode itself had a 0.373 inch diameter and a length of 1.38 inches. Approximately 70% of the exterior surface of the anode itself was adhered by brazing to the interior surface of the cap 43. The surfaces 44 and 46 are plated respectively with silver and molybdenum manganese plus nickel prior to the anode being assembled within the cylinder 42. The diameter of the anode is slightly less than the diameter of the interior surface 46 of such cylinder. The result is that these parts easily can be mechanically assembled together. They are then raised to the brazing temperature. The coefficient of thermal expansion of OFHC copper, the preferred material for anode 43, is  $20.1 \times 10^{-6}$  in/in/ $^{\circ}$  C. whereas the coefficient of thermal expansion of BeO, the preferred material for cylinder 42, is  $8.5 \times 10^{-6}$  in/in/ $^{\circ}$  C. This fact is used in the instant invention to enhance the adherence of the anode to the tube. That is, upon these parts being raised to the brazing temperature, the thermal expansion of the metal anode 43 in the radial dimension will be greater than the thermal expansion of the cylinder. There therefore is a tight mechanical fit during brazing. This assures that a thin braze which provides a good thermal path between the anode and cylinder, is achieved. The silver plated copper forms a copper/silver eutectic which flows at  $800^{\circ}$  C. and forms the necessary braze alloy to make the joint. Due to the extreme ductility of OFHC copper at the braze temperature, the tensile forces on the ceramic do not break it.

It will be recognized that when the assembly is returned to ambient temperature, the radial dimension of the anode 43 will tend to shrink to a greater extent than the radial dimension of the interior surface of the cylinder 42. The result is that some stress will be built up between the parts 42 and 43. However, this stress is spread over a significant surface area in view of the fact that the braze covers a relatively large surface area, and the joint and structures can accommodate the same.

The configuration of the electrode relative to the cylinder 42 also aids in achieving the desired adherence. It has a radially thick first portion 47 which

includes an axial passageway for the passage there through of optical radiation, and a radially thin second portion which, in effect, defines a thin-walled sleeve 48. The surface 44 of the anode which is adhered to the surface 46 of the end cap is provided as illustrated by both the portions 47 and 48. As mentioned previously, the dimensional change in a metal due to thermal variations is significantly greater than that of a ceramic. The coefficient of thermal expansion of a material is a measure of such change.

The electrode configuration is selected to enhance laser operation. That is, the portion of the same at which significant thermal energy is generated, i.e., its first portion, is radially thick for good thermal conductivity. The free end of the thick-walled portion is conical in shape to increase its surface area for distribution of the discharge. The thin-walled sleeve 48 integral therewith allows desired electrical conductivity, but minimizes thermal conductivity from the discharge because of its thinness. In other words, the configuration of the anode provides good thermal conductivity in the radial direction but not in the axial direction. The fact that the thin-walled sleeve is an integral part of the anode, i.e., the anode is a one-piece construction, assures good electrical conductivity. (Col. 4, line 51 – Col. 6, line 12)

It is also well known that gas ion lasers are totally unsuited for the types of high pulse repetition rates according to the above described environment of the electrodes according to the present invention. Indeed, they are or were used in an on-off mode of relatively continuous operation, compared to pulsed operation at pulse widths measured in nanoseconds, generally require a preheating time to heat at least one of the electrodes before creating the discharge between the electrodes. They are not subject to the complications of utilizing a laser gas comprising fluorine, and do not utilize an elongated electrode with a small portion thereof comprising a discharge region. For more details on ion gas discharge lasers see [http:// repairfaq.cis.upenn.edu/sam/laseraps.htm#apsbcs1](http://repairfaq.cis.upenn.edu/sam/laseraps.htm#apsbcs1) and [http:// www.rli.com/resources/argon.asp](http://www.rli.com/resources/argon.asp) copies of the content of which are included along with this Brief.

In short gas ion lasers are totally foreign to excimer gas discharge lasers of the type disclosed and claimed in the present application such that, even if Weidemann taught or

suggested machining and then annealing an electrode for the purposes outlined above in the quoted portion of the Specification of the above captioned application, which Weidemann does not teach or suggest, persons of skill in the art would not look to electrodes utilized in ion gas laser tubes of the type described in Weidemann for solutions to totally foreign and distinct problems presented by excimer gas discharge lasers of the type disclosed and claimed in the present application. Weidemann himself notes that he uses annealing to accommodate differential thermal expansion and for better “securance.”

In any event, Weidemann does not disclose an electrode that is machined and then annealed. In the noted portions of Weidemann cited above, Weidemann teaches, at best, that the construction taught by Weidemann is facilitated – the cracking of the surrounding ceramic cylinder is made less likely - if one uses an annealed metal, or better yet, the preferred pure copper anode, such that at brazing temperature the copper becomes ductile enough that the ceramic will not crack.

Baumler discloses an electrode for a gas discharge laser that contains copper, aluminum, nickel and iron. What Baumler does not disclose is the electrode in question is the anode. Applicants have discovered that long life characteristics for such gas discharge electrodes in the excimer gas discharge laser environment utilizing a laser gas comprising fluorine not only depends upon the material from which the particular electrode is made, but that from which its opposing electrode is made. Baumler says nothing about selection of only one electrode, the anode as claimed, as opposed to using the same electrode composition for both anode and cathode. Baumler also does not disclose any electrodes containing anything more than a trace amount of zinc and discloses nothing of lead in the alloy.

## **II) Applicable Law**

Whether or not the Examiner has established *prima facie* obviousness allocates the burden of going forward with the evidence during the examination process.<sup>1</sup> Initially the burden of going forward is on the Examiner to establish *prima facie* obviousness

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<sup>1</sup> M.P.E.P. §2142. See *In re Rinehart*, 531 F.2d 1048, 189 U.S.P.Q. 143 (C.C.P.A. 1976); *In re Linter*, 458 F.2d 1013, 173 U.S.P.Q. 560 (C.C.P.A. 1972); *In re Saunders*, 444 F.2d 599, 170 U.S.P.Q. 213 (C.C.P.A. 1971); *In re Tiffin*, 443 F.2d 394, 170 U.S.P.Q. 88 (C.C.P.A. 1971), *amended*, 448 F.2d 791, 171 U.S.P.Q. 294 (C.C.P.A. 1971); *In re Warner*, 379 F.2d 1011, 154 U.S.P.Q. 173 (C.C.P.A. 1967), *cert. denied*, 389 U.S. 1057 (1968).

otherwise the applicant has no obligation to submit evidence of nonobviousness.<sup>2</sup> *Prima facie* obviousness is established by a “suggestion or motivation,” either in the references themselves or in the ordinary skill of the art, to modify the reference or to combine references, a “reasonable expectation of success,” and the combination must teach or suggest all the claim limitations.<sup>3</sup> Initially the Examiner must show “some suggestion of the desirability of doing what the inventor has done.”<sup>4</sup> Either “the references must expressly or impliedly suggest the claimed invention” or the Examiner “must present a convincing line of reasoning as to why the artisan would have found the claimed invention to have been obvious in light of the teachings of the references.”<sup>5</sup> The Examiner is also required to show from the record that the suggestion to combine is in the references and bald statements of obviousness to combine, or that the combination “involves routine skill in the art” cannot stand under *In re Lee*, 277 F.3d 1338, 1345, 61 U.S.P.Q.2d 1430 (Fed. Cir. 2002) (“ ‘deficiencies of the cited references cannot be remedied by the Board's general conclusions about what is “basic knowledge” or “common sense.” ’ The Board's findings must extend to all material facts and must be documented on the record, lest the “haze of so-called expertise” acquire insulation from accountability.”) or *In re Thrift*, 298 F.3d 1357, 1362, 63 U.S.P.Q.2d 2002 (Fed. Cir. 2002) (finding of obviousness as to one claim was proper where references themselves suggested combination but that simple assertion that “[t]he use of grammar is old and well known in the art of speech recognition as a means of optimization which is highly desirable,” did not make out a case of *prima facie* obviousness).

Unless the motivation to combine the references is “immediately apparent,” The Examiner must explain why the combination is proper.<sup>6</sup> The prior art must be analogous art. Analogous art must either be in the field of applicant’s endeavor or, if not, then reasonably

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<sup>2</sup> M.P.E.P. §2142.

<sup>3</sup> M.P.E.P. §2142. Such teaching or suggestion and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. M.P.E.P. §2142. See *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991). See M.P.E.P. §§ 2143 - 2143.03 regarding these criteria.

<sup>4</sup> M.P.E.P. §2142.

<sup>5</sup> M.P.E.P. §2142. *Ex parte Clapp*, 227 USPQ 972, 973 (Bd. Pat. App. & Inter. 1985). See M.P.E.P. §§2144 - 2144.09 regarding reasoning supporting obviousness rejections.

<sup>6</sup> M.P.E.P. §2142. See *Ex parte Skinner*, 2 U.S.P.Q.2d 1788 (Bd. Pat. App. & Inter. 1986). A rejection including numerous grounds for rejections must explain with “reasonable specificity” at least one rejection, or no *prima facie* obviousness exists. M.P.E.P. §2142. See *Ex parte Blanc*, 13 U.S.P.Q.2d 1383 (Bd. Pat. App. & Inter. 1989) (rejection based on nine references with at least 40 prior art rejections and no explanation of any one rejection with reasonable specificity reversed).

pertinent to the particular problem with which the inventor is concerned.<sup>7</sup> The art relied upon must be something that “logically would have commended itself to the inventor’s attention.” *Clay, supra*.

For *prima facie* obviousness all of the claim limitations must be taught or suggested by the prior art.<sup>8</sup> If an independent claim is nonobvious any claim depending from the independent claim is also nonobvious.<sup>9</sup>

Regarding claims 2-11 the Examiner seems to be applying a rejection of “obvious to optimize,” apparently relying on, without citation, the application of *In re Aller*, 220 F.2d 454, 456, 105 U.S.P.Q. 233, 235 (C.C.P.A. 1955) (“[W]here the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation.”). *In re Aller* and like “obvious to experiment” or “obvious to optimize” cases require that the parameter to be experimented with or optimized at least be known in the art as a “result determining variable.” See, M.P.E.P. §2144.05, citing, *In re Antonie*, 559 F.2d 618, 195 U.S.P.Q. 6 (C.C.P.A. 1977) (without recognition in the art that waste treatment device capacity was a function of tank volume to contractor ratio the ratio was not a “result effective variable” for purposes of a rejection based upon optimization by routine experimentation.) Here there is no teaching or suggestion that any of the component elements claimed in claims 2-11 are result determining or result effective variables to be optimized for the excimer laser electrode environment to get longer life electrodes.

### III) Analysis

**1) Issue 1** Whether claims 1 and 18-22 are patentable under 35 U.S.C. §103 (a) over Meller in view of Weideman.

Regarding the rejection of claims 1 and 18, there is no *prima facie* case of obviousness because:

#### **a) Non-analogous Art**

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<sup>7</sup> M.P.E.P. §2141.01 (a), citing, *In re Oetiker*, 977 F.2d 1443, 1446, 24 U.S.P.Q. 2d 1443, 1445 (Fed. Cir. 1992), *In re Clay*, 966 F.2d 656, 659, 23 U.S.P.Q.2d 1058, 1060-61 (Fed. Cir. 1992) and *Wang Laboratories Inc. v. Toshiba Corp.*, 993 F.2d 858, 26 U.S.P.Q. 2d 1767 (Fed. Cir. 1993).

<sup>8</sup> M.P.E.P. §2143.03. See *In re Royka*, 490 F.2d 981, 180 U.S.P.Q. 580 (C.C.P.A. 1974); *In re Wilson*, 424 F.2d 1382, 1385, 165 U.S.P.Q. 494, 496 (C.C.P.A. 1970) (must consider all of the claim language).

<sup>9</sup> M.P.E.P. §2143.03. See *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596 (Fed. Cir. 1988).



For the reasons noted above Weidemann is not analogous art. It involves technology not addressing the same or similar problems that applicants invention addresses also as noted above. Persons of ordinary skill in the art would not look to Weidemann or prior art like Weidemann for the solutions to the lifetime of electrodes in gas discharge lasers, e.g., excimer lasers with fluorine gas in the laser chamber.

**b) No suggestion to Combine**

2. For the reasons noted above there is no teaching or suggestion in either Meller or Weidemann or in any other art or reasoning of the Examiner, beyond a bald statement of obvious to combine, to combine the Meller and Weidemann references nor one that has any hint of an expectation of success in using Weidemann to address the problems addressed by the claimed invention in its environment that so differs from the Weidemann environment.

There is nothing to suggest that annealing of an electrode in an ion laser with a completely different operating environment, and for completely different purposes (differential thermal expansion compensation and better “securance” as opposed to reducing electrode erosion wear in a harsh excimer gas discharge laser environment) would suggest making electrodes for excimer lasers to solve the problems associated with electrode wear. Weidemann is for this reason also non-analogous art. Looking to the teachings of Weidemann would not have logically suggested itself to the applicant because it was not at all related to the problem that the inventor was trying to solve.

**c) Combination Lacks Claimed Elements**

For the above stated reasons, the combination does not result in all of the claimed elements. Weidemann does not teach or suggest an electrode that has been both machined and annealed, much less one that is first machined and then annealed. Further, the Examiner’s suggestion that Weidemann’s silence on whether to anneal first and then machine or vice-versa means that Weidemann teaches doing it either way is not supported in fact or law. Indeed, Weidemann does not even say that the shape of the anode piece is formed by machining at all. It could just as well be cast or molded.

**d) Product By Process Claims**

The Examiner’s removal from consideration of patentability of the recitations in claim 18 of the “annealed after machining” phrase is not proper. Such a recitation is an

entirely proper “product by process” recitation in an apparatus claim and does not change the claim from an apparatus claim to a method claim. Here, in addition to the recitation of a process for manufacturing the product, the resultant properties are also recited rather than being left to implication<sup>10</sup> In the present case the process, machining and then annealing, leads to the recited distinguishing features, e.g., “reduced stress and reduced exposed metallic grain boundary length on the surface,” which are distinguishing features.

With respect to claims 19-22, these claims should be allowed as dependent from an allowable claim *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596 (Fed. Cir. 1988). In addition the Examiner improperly refused to consider product-by-process limitations in the claims that further distinguish the claims from the art. As noted above, product by process claims are proper and the properties imparted to the product should be considered in defining the invention over the art. Applicant submits that the annealing steps recited in claims 19-22 impart properties to electrodes for fluorine based gas discharge lasers such as excimer lasers that are not taught or suggested in the art and the specifics of the annealing process is properly recited in a product by process format in claims 19-22.

**2) Issue 2** Whether claims 2-11 are patentable under 35 U.S.C. §103 (a) over Meller in view of Weidemann and Baumler.

With regard to claims 2-11, they are dependent from allowable claim 1 and should be allowed for that reason. *In re Fine, supra*. In addition, the above arguments **1 a)**, **1b)** and **1c)** respecting the applicability of the art to claim 1 apply also to the dependent claims 2-11.

In addition elements of the claims 2-11 are not found in the combination of Meller, Weidemann and Baumler. Applicant has discovered that long life characteristics for gas discharge laser electrodes, e.g., in an excimer gas discharge laser environment utilizing a laser gas comprising fluorine not only depends upon the material from which the particular electrode is made, but that from which its opposing electrode is made.

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<sup>10</sup> The structure *implied by* the process steps should be considered when assessing patentability of product-by-process claims over the prior art, especially where the product can only be defined by the process steps by which the product is made, or where the manufacturing process steps would be expected to impart distinctive structural characteristics of the final product. M.P.E.P. §2113, *citing, In re Garnero*, 412 F.2d 276, 279, 162 U.S.P.Q. 221, 223 (C.C.P.A. 1979)

Baumler says nothing about selection of only one electrode, the anode as claimed, as opposed to using the same electrode composition for both anode and cathode. Therefore, as to claims 2-4 the combination of Meller, Weidemann and Baumler, in addition to the elements missing in the combination of Meller and Weideman, as applied to claims 1 and 18, does not contain all of the elements of claims 2-4.

With respect to claims 5-7, the above argument is even more persuasive since the claims recite one alloy composition for the anode and a different one for the cathode. The art, i.e., Baumler, does not suggest what alloy component is the result effective variable for such an optimization, and further does not suggest performing differing modifications on the anode and on the cathode arriving at the claimed differing compositions for the anode and cathode respectively.

The same argument apply as well to claims 8-11. In addition as to claims 8-11 the argument of the Examiner does not reach the level of a *prima facie* case of obviousness for the reason that Baumler does not even mention lead. Thus in addition to the lack of *prima facie* obviousness from the prior art teaching similar alloy compositions, but not what is to be optimized and not the use of differing compositions for the anode on the one hand and the cathode on the other, all of the claimed elements are not found in the art as to claims 8-11.

**d) Improper Application of Obvious to Optimize**

In addition, the application by the Examiner of, e.g., *In re Aller*, 220 F.2d 454, 456, 105 U.S.P.Q. 233, 235 (C.C.P.A. 1955) (“[W]here the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation.”) is not proper. The statement of the law in *Aller* has been limited to optimizations of known result determinative variables. See, Sheldon, J. “Manual of Patent Examining Procedure 2144 Sources of Rationale Supporting a Rejection Under 35 U.S.C. 103,” PLI Practicing Law Institute How to Write Pat. App. C 2144 Appendix C (2001) (“particular parameter must first be recognized as a result-effective variable, i.e., a variable which achieves a recognized result, before the determination of the optimum or workable ranges of said variable might be characterized

as routine experimentation”).<sup>11</sup> See also, M.P.E.P. §2144.05 (recognizing the limited applicability of *In re Aller*, to cases involving the “optimization of ranges,” and even then, the optimization must be of a variable that is recognized in the teaching of the art to be a “result-effective variable.”)<sup>12</sup>

Applicant submits that not only does the art not suggest which components of the alloy should be modified for result effective optimization, but also does not suggest that different modifications be made to the anode on the one hand and the cathode on the other.

In addition, this is not even a case of *prima facie* obviousness in the selection of a claimed range where the prior art range is overlapping. See, Patent Law Fundamentals, Second Edition Mills III, et al. Eds, “The Substantive Requisites of a Valid Patent Chapter 10. Nonobviousness § 10:14 (2003) (“*prima facie* obviousness has also been held established in instances in which the only physical difference between what was claimed and prior art was numerical. Examples include ... cases where an overlap existed between the claimed range of numerical values and prior art numerical values).<sup>13</sup> And even if the ranges in the art and in the claim do not need to be overlapping or touching, they at least need to be close enough for the art to consider the teachings close enough to show the particular range that is suggested for optimization. See, *Gentiluomo v. Brunswick Bowling & Billiards Corp.*, 36 Fed. Apex 433, 438 (Fed. Cir. 2002) (unreported opinion stating the ranges need not overlap) and *Ex Parte Brunsveld*, 2001 WL 1057401 (Bd.Pat.App & Interf. 2001) (upper limit of about 12% in the reference and

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<sup>11</sup> Id., citing, *In re Antonie*, 559 F.2d 618, 195 U.S.P.Q. 6 (C.C.P.A. 1977) (claimed wastewater treatment tank volume to contractor area ratio was not recognized in the art to be a factor upon which treatment system capacity could be optimized and was, therefore not a result-effective variable.) and *In re Boesch*, 617 F.2d 272, 205 USPQ 215 (CCPA 1980) (prior art did suggest the balancing of a certain proportion as result effective).

<sup>12</sup> M.P.E.P. §2144.05 (the variable is one which is recognized to achieve a recognized result “before the optimum or workable ranges of said variable might be characterized as routine experimentation.”)

<sup>13</sup> Id., citing, *In re Malagari*, 499 F.2d 1297, 1302-03, 182 U.S.P.Q. (BNA) 549, 553 (C.C.P.A. 1974); *In re Ornitz*, 53 C.C.P.A. 716, 351 F.2d 1013, 1017, 147 U.S.P.Q. (BNA) 283, 286 (1965); *In re Nehrenberg*, 47 C.C.P.A. 1159, 280 F.2d 161, 164, 126 U.S.P.Q. (BNA) 383, 385 (1960). See also, *Ex Parte Gibson*, 1998 WL 1766677 (Bd.Pat.App & Interf. 1998) ( it is known in the art to provide a blade with as few as one and as many as 10 turns and to vary the length of the spike, clearly establishing that the particular number of turns and the length of the spike are result effective variables which are recognized in the art. This being the case, the selection of an optimum value for such variables is ordinarily an obvious matter which is within the skill of the art.” citing, *In re Geisler*, 116 F.3d 1465, 1469, 43 U.S.P.Q. 2d 1362, 1365 (Fed. Cir. 1997), and *In re Boesch*, 617 F.2d 272, 276, 205 USPQ 215, 219 (CCPA 1980).

lower limit of about 15% in the claim were close enough that “*prima facie* one skilled in the art would have expected the compositions to have the same or similar properties.”)

This simply cannot be said about Baumler’s disclosure of “trace amounts of other elements, such as zinc or manganese,” (Col. 2, line 46) and the claimed 25% zinc. Further as noted above, Baumler neither teaches nor suggests anything approaching the claimed different compositions being used for the anode on the one hand and the cathode on the other and cathode.

For the above stated reasons the Examiner’s rejections of claims 1-11 and 18-22 are improper and claims 1-11 and 18-22 should be allowed.

#### IV) Summary

Claims 1 and 18 are not unpatentable over Meller and Weideman because the Examiner has not made a *prima facie* case of obviousness, because the art, including Weidemann, would not suggest the combination of Weidemann with Meller to solve the problems the inventor was addressing, which is even more compelling since Weidemann is not analogous art and Weidemann does not disclose machining and annealing much less machining first and then annealing. Claims 19-22 for the same reasons are not unpatentable over Meller and Weidmann because the Examiner has not made a *prima facie* case for obviousness and in addition are patentable under *In re Fine, supra*. Claims 2-11 are not unpatentable over Meller, Weidemann and Baulmer under *In re Fine, supra*, and in addition because there is no *prima facie* case of obviousness for the reasons discussed with respect to claim 1 and also since Baulmer does not teach or suggest making the anode of one alloy and the cathode of another. Further with respect to claims 8-11 Baumler fails to disclose lead at all. The Examiner has improperly refused to consider product by process limitations in claims 18-22 and has improperly applied the ‘obvious to optimize’ rationale to the claims on appeal.

**Conclusions**

Claims 1-11 and 18-22 are in a condition for allowance and should be allowed and the Board is respectfully requested to instruct the Examiner to withdraw the rejections of claims 1-11 and 18-22 and allow claims 1-11 and 18-22.

Applicants have previously authorized the Commissioner to charge \$330.00 and any additional fees due, or to credit any overpayment for the filing of this Substitute Appeal Brief to Cymer, Inc.'s Deposit Account No. 03-4060.

Respectfully submitted,



William C. Cray; Reg. No. 27,627

June 21, 2004  
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Stephanie Sharrett

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Stephanie Sharrett  
(Signature of Person faxing papers or fees)

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of:

Richard G. Morton

Serial No.: 09/742,485

Filing Date: December 20, 2000

Title: ANNEALED COPPER ALLOY  
ELECTRODES FOR FLUORINE  
CONTAINING GAS DISCHARGE  
LASERS

Examiner: D. Monbleau

Group Art Unit: 2878

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Alexandria, VA 22313-1450

**APPENDIX A TO APPLICANTS' SUBSTITUTE APPEAL BRIEF**

**Claims**

1. (Previously amended) An excimer laser with long life electrodes said laser comprising:
  - A) a laser chamber containing a laser gas comprising fluorine;
  - B) an electrode set comprising an elongated machined and annealed copper alloy cathode and an elongated machined and annealed copper alloy anode;
  - C) a circulating means for circulating said laser gas between said elongated electrode;

D) a pulse power electrical system for generating electrical pulses between said electrode to produce a laser gain medium.

2. (Original) A laser as in claim 1 wherein said elongated anode is comprised of at least 70% copper and 7% aluminum.

3. (Original) A laser as in claim 2 wherein said elongated anode also is comprised of nickel and iron.

4. (Original) A laser as in claim 3 wherein said elongated anode is comprised of approximately 82% Cu, 10% Al, 5% Ni and 3% Fe.

5. (Original) A laser as in claim 1 wherein said elongated cathode is comprised of at least 50% copper and at least 25% zinc.

6. (Original) A laser as in claim 3 wherein said elongated cathode is comprised of at least 50% copper and at least 25% zinc.

7. (Original) A laser as in claim 4 wherein said elongated cathode is comprised of at least about 70% copper and at least 25% zinc.

8. (Original) A laser as in claim 5 wherein said elongated cathode is also comprised of lead.

9. (Original) A laser as in claim 8 wherein said elongated cathode is comprised of approximately 61.5% copper, 35.5% zinc and 3% lead.

10. (Original) A laser as in claim 8 wherein said elongated cathode is comprised of approximately 70% copper, 29.93% zinc and 0.07% lead.



11. (Original) A laser as in claim 4 wherein said elongated cathode is comprised of approximately 70% copper, 29.93% zinc and 0.07% lead.

12. (Cancelled)

13. (Cancelled)

14. (Cancelled)

15. (Cancelled)

16. (Cancelled)

17. (Cancelled)

Please add the following new claims:

18: (Previously added) An excimer laser with long life electrodes said laser comprising:

A) a laser chamber containing a laser gas comprising fluorine;

B) an electrode set comprising an elongated machined and annealed copper alloy cathode and an elongated machined and annealed copper alloy anode, each of which is annealed after machining in order to reduce surface stress and to reduce exposed metallic grain boundary length on surfaces of said cathode and anode;

C) a circulating means for circulating said laser gas between said elongated electrode;

D) a pulse power electrical system for generating electrical pulses between said electrode to produce a laser gain medium.

19. (Previously added) The apparatus of claim 1 further comprising:

said anode and said cathode each being the product of a process comprising annealing said anode and said cathode at substantially above 600°C.

20. (Previously added) The apparatus of claim 18 further comprising:

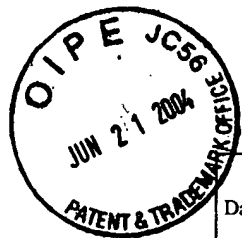
said anode and said cathode each being the product of a process comprising annealing said anode and said cathode at substantially above 600°C.

21. (Previously added) The apparatus of claim 19 further comprising:

said anode and said cathode each being the product of a process comprising annealing said anode and said cathode at least 50°C below the softening point for the alloy respectively comprising the anode and the cathode.

22. (Previously added) The apparatus of claim 19 further comprising:

said anode and said cathode each being the product of a process comprising annealing said anode and said cathode at least 50°C below the softening point for the alloy respectively comprising the anode and the cathode.



USSN 09/742,485  
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Stephanie Sharrett

(Typed or Printed Name of Person faxing papers or fees)

Stephanie Sharrett  
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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

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Examiner: D. Monbleau

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**APPENDIX B TO APPLICANTS' SUBSTITUTE APPEAL BRIEF**

1. Basic Ar/Kr Ion Laser Power Supply Considerations, [http:  
//repairfaq.cis.upen.edu/sam/laseraps.htm #apsbcs1](http://repairfaq.cis.upen.edu/sam/laseraps.htm#apsbcs1)
2. The Argon Gas Laser System, [http // www. rli. resources /argon.asp](http://www.rli.resources/argon.asp)

## Basic Ar/Kr Ion Laser Power Supply Considerations

<http://repairfaq.cis.upenn.edu/sam/laseraps.htm#apsbcs1>

Small air-cooled Ar/Kr ion tubes require an operating voltage of around 100 to 110 VDC at 3 to 10 AMPs and a starting voltage of about 8 to 10 kV (but almost no current). While these basic requirements are in some ways similar to those of a HeNe tube, the sheer value of the current - measured in AMPs - means that providing a power supply that doesn't self destruct, destroy the laser tube, or fry you in the process, is much more of a non-trivial task.

Note: Most parameters here are given for argon ion tubes since these are most common. However, while physically interchangeable krypton and mixed gas ion tubes are very similar electrically, they will have slightly lower starting and operating voltages. This isn't a problem for starting, but the difference in operating voltage can be significant enough to cause some power supply compatibility problems such as excessive power dissipation in the regulator circuits. This should be kept in mind if substituting tube types. See the section: Comparison of Argon and Krypton Ion Tube Characteristics for a specific example.

- The typical discharge voltage is 100 to 110 VDC into very nearly a short circuit - very low ohms. Theoretically, it is not a negative resistance as with a HeNe tube, at least. However, a combination of factors can still result in runaway if the effective series (ballast) resistance of the system is too low.

The source for the operating voltage is either a direct line-connected rectifier/filter 'front-end' or this followed by a high frequency inverter. (RF excitation is also possible but I don't know of any commercial examples of this approach.)

- Operating current must be controlled and variable (to adjust beam power) from around 3 A to 10 A (which is the usual maximum specified current though more may be used in some cases and for larger lasers). Feedback based on tube current and direct optical monitoring of the beam (light control) is a must for continuous unattended operation. This provides the lowest noise and maximizes tube life. Modulation of the beam power can also be provided via an external input.

A series linear or switchmode (buck) regulator may be used with the line connected supply. Some power supplies use a combination of a switchmode preregulator to drop the rectified filtered line voltage to a range where a linear regulator can run with reduced power dissipation and use fewer, lower cost pass-transistors. Inverters will use PWM control of their drive.

- The Ar/Kr ion tube uses a heated filament-cathode. This requires a separate 2.5 to 3 V supply at 15 to 25 AMPs. The cathode must be up to operating temperature (usually about a 30 second to 1 minute delay from power-on in PREHEAT mode) prior to initiating the discharge to prevent damage to the tube. Commercial power supplies provide this delay automatically.

A simple low voltage power transformer with a centertapped secondary usually supplies the filament current. Fine adjustment of filament current can be done using a tapped primary or Variac. The use of AC is actually beneficial and helps to spread the heat from the discharge over the extent of the cathode (filament) by dithering the arc position.

Note that although the plasma temperature is extremely high, this is only true in the actual bore - which may start several inches away from the filament. Thus, you really do want the filament powered prior to initiating the discharge and at all times while it is running. If the filament loses power for some reason and cools down, the voltage drop between the filament and the discharge will increase leading to much greater power dissipation and hot spots. Depending on the main DC power supply, the discharge may just go out without any harm but for some, this may not be the case and the regulator may keep trying to maintain the specified current as the tube voltage climbs. I don't know how many times you can get away with this and how quickly it will damage or kill a tube but would rather not find out!

- The starter (generally called an igniter in this case - sounds much more impressive, doesn't it?!), must be designed taking into consideration that the full discharge current must pass through any blocking diodes or series

inductor/transformer. Therefore, those whimpy parasitic multipliers used for HeNe tubes will not work!

A design discharging a capacitor into a high current high voltage pulse transformer is normally used.

- Finally, while not strictly a power requirement, these Ar/Kr ion tubes requires LOTS of cooling. The air-cooled type must have a HUGE fan passing air through the elaborate heat sink fins of the tube with all plenums and/or baffles in place. After all, it will be dissipating 1,000 W OR MORE at full power - about the same as a medium size space heater!
- And, most important: Safety, electrical, and thermal protection and interlocks MUST be provided for this sort of high power laser equipment. Circuit failure or carelessness can result in unfortunate consequences. Optical shutters, beam-on indicators, and all other CDRH required laser safety devices are also essential.

Note that what we are talking about are Ar/Kr ion tubes putting out up to a few hundred mW of beam power. These are not small by HeNe laser standards. The lowest power models are still about 12 inches (30 cm) long with a diameter (including all the cooling fins and other attached structure) of about 4 inches (10 cm).

Large frame Ar/Kr ion tubes can be over a meter in length and nearly everything about them is, well, much larger. :-) There are even 8 FOOT (2.5 m) long monster medical lasers that output 35 W or more and require over 600 V at 35 A to power the tube. Figure on a direct feed from a local electric utility substation for this kind of power! Ion lasers like these may also have axial permanent or electro-magnets surrounding the tube to concentrate the discharge and other 'stuff' that we will kind of ignore. ;-) They also require several gallons per minute from a tap or chilled water source to prevent a melt-down.

For these reasons, while the offer of a cheap or free large frame ion laser may sound tempting, consider the power and cooling requirements before dragging it home. It will likely end up as a coffee table support or high-tech sculpture if you don't have industrial strength three-phase power at your disposal! Cooling water may also be a problem. Nonetheless, most of the basic information on small air-cooled ion lasers DOES apply to their bigger brothers as well if the numbers are adjusted appropriately. And, the power supplies are quite similar. In fact, the same power supply can often be used for a wide variety of ion lasers by selecting the AC input and changing some jumpers.

Throughout this chapter, references will be made to several commercial Ar/Kr ion lasers systems. Two of the most common are:

- American Laser Corporation (Salt Lake City, Utah), Model 60X second sourced as the Omnicrome (now a division of the Melles Griot Laser Group, Carlsbad, CA) model 532 (designated the ALC-60X/Omni-532). The general features of this laser are described (with photos) in the chapter: Argon/Krypton Ion Lasers. This is a small air-cooled argon ion external mirror tube good for up to several hundred mW on all or selected lines (depending on specific model). This is the most common laser of this type and relatively widely - and increasingly available on the surplus market.

A few oddball versions of the 60X (60XB and 60XC) are still manufactured but the 532 is an obsolete model. American and Omnicrome both make/made a few zillion variations on the same theme. All of them look similar and have common features. American still makes replacement tubes for the 60X but they do much higher power with newer generation technology. Call ALC and request a generic brochure if you are curious (or more than curious).

Photos of Various Laser Systems, Power Supplies, and Components has detailed views of various argon/krypton ion lasers including examples of the 60 series from American Laser Corporation. However, note that the ALC power supply shown in the photos will drive the same laser heads, it is NOT the same implementation as the Omni-150R described in detail in the section: Omnicrome 150R Power Supply and 532 Laser Head (Omni-150R/532). They differ physically as well: The ALC (there are a variety of versions) is in an elongated goldish-aluminum ("Alodined") box (as in the photos) while the Omni is shorter and painted black.

- Lexel Laser, Inc. (now out of business) Model 88 (designated the Lexel-88). They have various argon, krypton, and mixed gas ion lasers with up to several WATTS of beam power using the same linear power supply (though apparently not sold with the relatively small Model 88 anymore. This series is probably the next most commonly available ion laser compared to the ALC-60X/Omni-532.

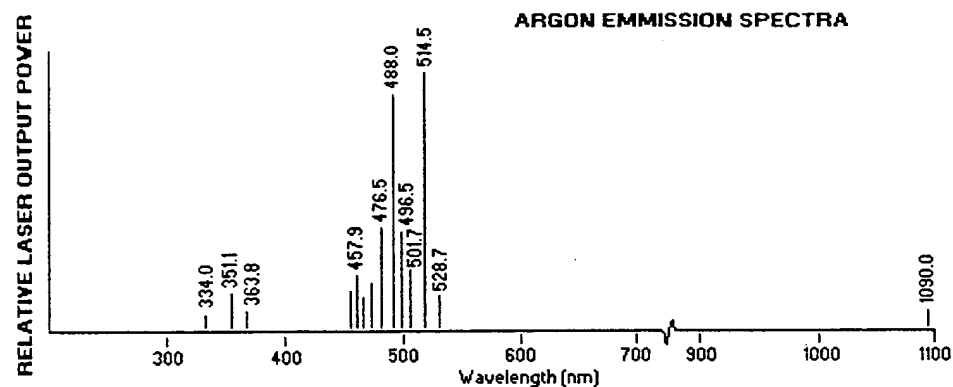
Complete schematics of the power supplies and typical laser heads for these units are provided in the chapter: Complete Ar/Kr Ion Laser Power Supply Schematics.



## The Argon Gas Laser System

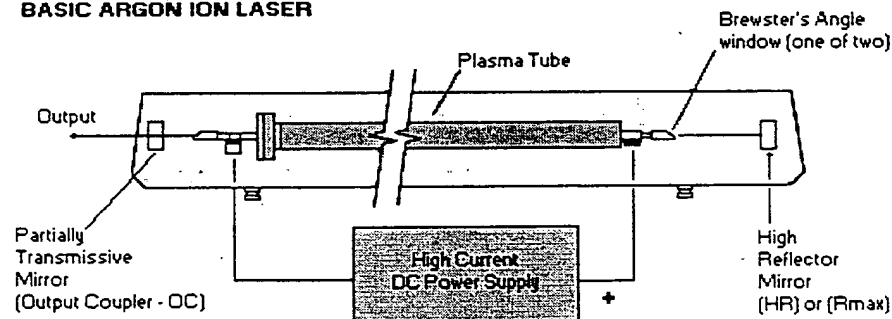
The Argon laser was invented in 1964 by William Bridges at Hughes Aircraft and is one of a family of ion lasers that use a noble gas as the active medium. This laser is used in many applications such as:

- Forensic Medicine
- Entertainment
- General Surgery
- Ophthalmic Surgery
- Holography
- Optical "pumping" source



This image shows all the wavelengths of light emitted by the Argon laser operating in multi-mode. Every wavelength is a monochromatic light source of itself and each wavelength has a very narrow bandwidth. The two dominant wavelengths, of 514nm "Green" and 488nm "Blue" make up about 67% of the total beam output power. Single line operation is also possible by inserting prisms, diffraction gratings and other optical devices to "filter out" the unwanted wavelengths. Of course, when single line operation is required, the total output power decreases dramatically as well.

**BASIC ARGON ION LASER**



The laser resonator is made up of two mirrors. One is highly reflective (HR) and other is a partially reflective mirror (OC). From this optic (the Output Coupler) the beam emerges as laser light. The Brewster's Angle optic mounted at both ends of the tube, minimizes reflection losses

while creating a polarized beam. When the laser is first turned on, a delay allows for temperature stabilization. Then a pulse of high voltage (8 kilovolts DC) ionizes the argon gas. Upon ionization, high DC current (45 Amps) and about 600 volts DC across the tube maintains a sufficient discharge to keep the gas ionized. The typical Argon laser tube has a tungsten bore which has a high melting point and allows the laser to operate at higher power levels with longer tube life.

<http://www.rli.com/resources/argon.asp>